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Managing Campfire Impacts in the Backcountry

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THE AUTHORS

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RESEARCH SUMMARY

The collecting and burning of wood in backcountry campfires have significant ecological and esthetic effects. The most important ecological effect is probably the elimination of large woody debris. Soil alteration in heavily used areas where campers are allowed or encouraged to build fires on previously undisturbed sites is also important. In most situations esthetic impacts are probably more severe than ecological impacts. The most common problems are proliferation of sites, elaborate fire ring construction, littering, and building fires on obtrusive sites such as in meadows.

The four basic strategies for managing campfire impacts are prohibition of fires, concentrating campfires on a few sites, dispersing fires to a large number of sites, and no action. The appropriateness of each strategy, which is dependent upon management objectives and characteristics of use and the environment, is discussed. Most areas are so diverse that strategies should vary between zones within each area. Each of these strategies will be effective only if a unique combination of management actions is taken.

The final two sections outline basic principles and procedures for promoting minimum impact campfire use and initiating a campsite rehabilitation program. These are two of the more complex and difficult actions that management may have to take.

PREFACE

This report provides a summary of information and experience related to the management of campfires in backcountry areas. Although campfires are a widespread and prominent sign of human use, their impacts and significance are poorly understood. Management responses to these impacts include visitor education, regulations, site rehabilitation, and acceptance of impacts. These actions are often ineffective and in conflict because technical information is limited and management strategies are ineffective.

The information presented in this report should provide for the development of effective campfire policies and for practical techniques for achieving objectives. The report consists of four sections. Section one reviews the kinds of campfire impacts and their significance. The discussion is detailed because most of the conclusions have been extrapolated from indirectly related studies. Section two discusses the advantages and disadvantages of alternative strategies for managing campfire impacts and the management actions which must be taken if the strategies are to succeed. (This section should be most relevant to planning.) Section three describes minimum-impact campfire techniques and means of conveying this information to the visitor. Section four outlines methods for rehabilitating campfire sites, drawing heavily on techniques that have been successful in the Pacific Northwest. The last two sections are presented in a "how-to-do-it" manner intended for the manager who wants to start a campfire management program. More detailed sources of information are referred to in the text.

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IMPACTS ASSOCIATED WITH CAMPFIRES

Fire sites, whetherspots of blackened ground or elaborate fireplaces, are one of the most obvious signs of human use and impact in the backcountry. Managers of many backcountry areas have become concerned with both the esthetic impacts of fire sites and the ecological impacts of collecting and burning wood. Despite a paucity of research on this subject, it is possible to evaluate these impacts from indirectly related sources.

Esthetic Impacts

In lightly used places, fire rings are often the only noticeable evidence of previous use (fig. 1). Even where rings have been destroyed, scattered charcoal and blackened rocks provide evidence that a site has been used before (fig. 2). Although this may be objectionable to visitors who are expecting to find absolutely pristine environments, most visitors sampled in nine backcountry areas actually preferred to find simple rock fire rings on campsites (Lucas 1980). As long as there are not numerous fire rings or an unnecessary proliferation of fire sites in any area, most visitors find fire sites to be a positive attribute.

Figure 1.—In infrequently used areas, old fire sites are often the only noticeable evidence of human use.

In addition to the proliferation of sites, the most significant esthetic problems occur when fire rings become elaborately constructed or filled with litter (fig. 3). In Yosemite National Park, for example, Lee (1975) found elaborately constructed facilities and copious quantities of litter to be major detractions from the visitors' overall trip satisfaction. Damage to trees and elimination of downed wood as a result of wood gathering are undoubtedly objectionable to some visitors but do not significantly reduce the satisfaction of most visitors (Lee 1975).

Effects of Trampling

Trampling as a result of wood gathering, along with trampling while getting water, are the major causes of impacts beyond campsite boundaries. In Great Smoky Mountains National Park, the area disturbed by firewood collection was typically more than nine times the size of the devegetated area around campsites (Bratton and others 1978). In the Sierra Nevada, Davilla (1979) found typical wood scavenging distances to be about 200 ft (60 m). Saunders (1979) has documented pronounced shifts in understory composition in areas disturbed primarily by firewood collection. Soil is usually compacted and surface organic matter is disturbed.

Effects on small fauna may be even more pronounced. Duffey (1975), for example, has shown that the invertebrate fauna is altered at even lower trampling levels than the flora. Although such subtle changes may not be apparent to the visitor, they do represent a change in natural conditions occurring on an area almost an order of magnitude larger than other campsite impacts.

Effects of Removing Downed Wood

There has been concern that firewood collection removes nutrients from collection sites. This should not be a problem in most cases, however, because very little of an ecosystem's nutrient capital is contained in the small boles and branches which are most frequently collected for firewood. Most of the nutrient capital is in the soil, and the tree components which in the long term are most important to nutrient cycling are the leaves or needles and twigs (see, for example, Weetman and Webber 1972; Weaver and Forcella 1977).

Boles and branches are also a relatively insignificant source of soil organic matter. Over the long term, leaves or needles and twigs contribute more organic matter than boles or branches, so removal of the larger size classes of downed wood should only slightly reduce total soil organic matter. However, removal of large boles eliminates the only source of large woody residue,

which, in contrast to leaves or needles, twigs, and bark, has a unique functional role which cannot be replaced by finer organic materials.

Decayed wood has a greater water holding capacity than either mineral soil or humus. It also accumulates nitrogen, phosphorus, and sometimes calcium and magnesium, and is a significant site for nitrogen-fixing microorganisms (Harvey and others 1979). Consequently, removal of large woody debris can indirectly affect nutrient cycles. In many forests, dead wood is a preferred substrate for the seedling establishment and subsequent growth of some species (Jurgensen and others 1977; Schreiner 1978). Ectomycorrhizal fungi are also concentrated in decayed wood, particularly on dry sites and during dry periods (Harvey and others 1979). These organisms develop a symbiotic association with the roots of most higher plants, improving the plant's ability to extract water, nitrogen, and phosphate from infertile soils. Therefore, elimination of woody debris, through collection of firewood, may reduce site productivity, particularly on droughty or infertile soils.

Macrofauna are also affected by removal of large woody debris. For example, a shelterwood cut, in which all residues larger than 3 inches (7.5 cm) in diameter were removed, had significantly fewer total arthropods and particularly fewer arachnids (spiders) than similar shelterwood cuts in which less downed wood was removed (Fellin 1980). Small mammal and bird populations can also be affected by wood removal, where food sources are altered and living places and protected sites are eliminated. Large mammal populations should be essentially unaffected.

Use of wood not lying on the ground causes additional esthetic and ecological impacts. Trees close to campsites usually show a "browse line" where campers have broken off lower branches. Saplings are often felled and mature trees are scarred in areas where most of the downed wood has been removed. Scars often make a tree more susceptible to fungal attack. In some cases, standing snags have also been cut down. This eliminates important habitat for cavity-nesting birds and impairs the esthetic qualities of the area.

Figure 2.—Even where fire rings have been broken up, the imprint of human use often remains in scattered charcoal and blackened rocks.

Figure 3.—Built-up firepit and rock chairs are disturbing to many visitors.

Effects of Campfires

Impacts resulting from campfires have been studied experimentally by Fenn and others (1976), although their experimental burns were probably more severe than typical campfires—140 lb (63.5 kg) of wood were ignited and allowed to burn completely, over 50 hours in some cases. They found that a single campfire altered organic matter to a depth of 4 inches (10 cm) or more, with a 90 percent loss of organic matter in the upper inch (2.5 cm) of soil. Impacts were less pronounced in fine-textured and moist soils, and where softwood fuels were burned.

Low-intensity fires, with temperatures below 400° F (200° C), may have relatively little effect on soil properties, while fires in which temperatures exceed 750° F (400° C) cause pronounced physical and chemical changes (Sertsu and Sanchez 1978). At temperatures above 750° F (400° C), most organic matter is consumed; most nitrogen, sulfur, and much phosphorus is lost; and the moisture-holding capacity and infiltration rates of the soil are reduced (Tarrant 1956; Miller and others 1974). Soil pH and the amounts of most cations increase (Isaac and Hopkins 1937). Fenn and others (1976) recorded maximum surface temperatures of campfires ranging from 350° F (180° C) to more than 1,340° F (730° C).

Fires also reduce the populations of mycorrhizal fungi. These populations may return to normal densities within a year of the burn, but species composition probably shifts and mycorrhizal seedlings remain less abundant for several years after fire (Tarrant 1956; Harvey and others 1976). Conifer reproduction has also been found to be less abundant and vigorous as much as 10 to 15 years after severe burns (Isaac and Hopkins 1937; Vogl and Ryder 1969).

Ash and charcoal from fires may also cause changes. Although generally favorable to growth, nutrients concentrated in ash can alter soil microorganism populations and lead to compositional changes in the understory. Surface charcoal increases soil temperatures; this can either increase seedling germination (De Keijzer and Hermann 1966) (fig. 4) or lead to increased heat injury and mortality (Tryon 1948). Tryon (1948) generally found little effect of charcoal on germination success, seedling growth, microorganisms, or mortality from damping-off fungi.

The effects of campfires, although perhaps not evident to most visitors, are pronounced and long lasting. If confined to very small areas—as individual fires are—the overall effects are probably insignificant. However, in many places dispersal of

campers and, therefore, their campfires is encouraged. For example, in a 325-acre (132-ha) area around two lakes in the Eagle Cap Wilderness, Oreg., we found 221 campsites, some of which had multiple fire sites (fig. 5). Moreover, on many sites rangers and some visitors remove fire rings. Through analysis of long-term photographs, we have found that fire rings are often rebuilt in new locations on the site, effectively "moving" the impacts around the site. In these situations campfires do affect the ecology of a large area.

Finally, careless campers can allow a campfire to become a wildfire. Techniques designed to minimize the danger of wildfire, such as clearing a large area down to mineral soil, are often highly destructive. In areas of high fire danger campfire management options are severely constrained by the opposing interests of resource protection and fire safety.

Figure 4.—On this campsite, tree seedlings are germinating only in the charcoal on the old fire site.

Figure 5.—Hundreds of old campfires mar the natural beauty and affect the ecology of this popular camping spot in the Eagle Cap Wilderness, Oreg.

Conclusions

Despite the lack of research specifically devoted to the impacts of firewood collection and burning, it is possible to draw some conclusions about probable effects. The frequently mentioned direct loss of nutrients is probably relatively unimportant; most of the probable ecological consequences of firewood collection and burning would be unnoticeable to most visitors. Large animals and live trees, for example, should be minimally affected. Undergrowth, small animals, and particularly microorganisms are more likely to experience changes in abundance and species composition.

Although the function of soil microorganisms in the ecosystem is poorly understood, the reduction of these populations, through removal and combustion of large woody material, trampling while gathering wood, and soil sterilization from the heat of the campfire, may be quite significant. Loss of mycorrhizal fungi may be of particular importance. The lack of mycorrhizal populations on many disturbed sites has led some authors to suggest that successful revegetation projects will depend upon an ability to maintain or reintroduce essential mycorrhizal fungi (Reeves and others 1979).

Some of these impacts could be reduced considerably if downed logs too large to break by hand were not removed for firewood. If these residues were left, changes in the soil's nutrient content and organic matter composition would be less significant and faunal habitats would be less severely altered. On the surface these logs provide sites protected from trampling where seedlings can regenerate (Schreiner 1978). They also provide natural dams, decreasing erosion potential. Incorporated into the soil, this woody debris provides important sites for microbial activity (Harvey and others 1979). Use of only smaller fuels would produce less charcoal and reduce visual evidence of previous fires. Finally, it would eliminate hacked and sawed-off logs.

Clearly, more research will be necessary before we understand the significance of firewood collection and burning. In particular, we need to know more about how long it takes for soils to recover from campfires. Although recovery rates will vary tremendously from site to site, observations of fire site recovery suggest that revegetation of well-used sites, even when assisted, will usually require at least 10 to 15 years. Less frequently used sites may recover more rapidly, but we have observed ''rehabilitated'' fire sites, used only once, where even visual recovery takes more than 1 year.

The effects of firewood collection then are probably insignificant except where wood supplies become so depleted that even large downed logs are used for firewood. This can occur with even moderate levels of use in forests or woodlands with low productivity and can occur on localized areas of heavy use in more productive forests. From both an ecological and a social perspective, the effects of campfires are also relatively insignificant—on account of their small size—except where they are allowed to proliferate or ''move around'' on a site. This situation can occur in moderately to heavily used areas where visitors are allowed to build fires wherever they want or where fire ring removal causes new rings to be built.

Figure 6.—Multiple fire sites on a single campsite are an esthetic problem. This campsite in the Selway-Bitterroot Wilderness has four fire sites, three in front and to the right of the boulder in the center and one in the meadow at the left.

The most significant esthetic problems are the proliferation of fire sites (fig. 6), elaborate fire ring construction, litter, and chopped trees and downed logs. These impacts are primarily a function of inappropriate visitor behavior and can happen anywhere.

CAMPFIRE MANAGEMENT STRATEGIES

Development of an effective management program for dealing with campfire impacts requires (1) establishing management objectives, (2) choosing between alternative management strategies, and (3) enacting a specific action plan based on the chosen strategy. Figure 7 displays necessary decisions in a logical order and summarizes the actions that must be taken for a selected strategy to work.

Within most backcountry areas the significance of both the ecological and the esthetic impacts of collecting and burning wood varies greatly between ecosystem types. Moreover, amount of use, a critical determinant of the impacts which occur, also varies widely, tending to be concentrated along trail corridors and at a few destinations. For example, ecological impacts are likely to be relatively pronounced in heavily used timberline forests and negligible in trailless areas of productive forest. Esthetic impacts are of most concern in nonforested areas or around attractions such as lakeshores. Consequently, most areas would profit from an internal zoning system in which several of the strategies discussed below are employed. Much of the discussion that follows is concerned with situations in which each strategy is and is not appropriate.

It is also important to coordinate campfire management with other aspects of campsite management. In addition to the combinations of management actions which must be taken for a given strategy to be effective, it is also important to make certain that these actions do not conflict with other elements of a campsite management program.

With this in mind, the first decision for any zone or backcountry area is whether or not to allow campfires. This may be a decision that all campfire impacts are unacceptable. In this case, all campfires would be prohibited even in lightly used areas. This may be an objective in a strict nature preserve, although, to be consistent, visitor use of all types should be curtailed. More common are areas where some impacts would be acceptable, but it is not possible to allow fires and keep their impacts to an acceptable level. This is the situation in heavily used areas where wood production is low, such as in timberline forests (fig. 8) or arid regions, or where the esthetic impacts of fires are particularly severe, such as in subalpine meadows close to lakes (fig. 9).

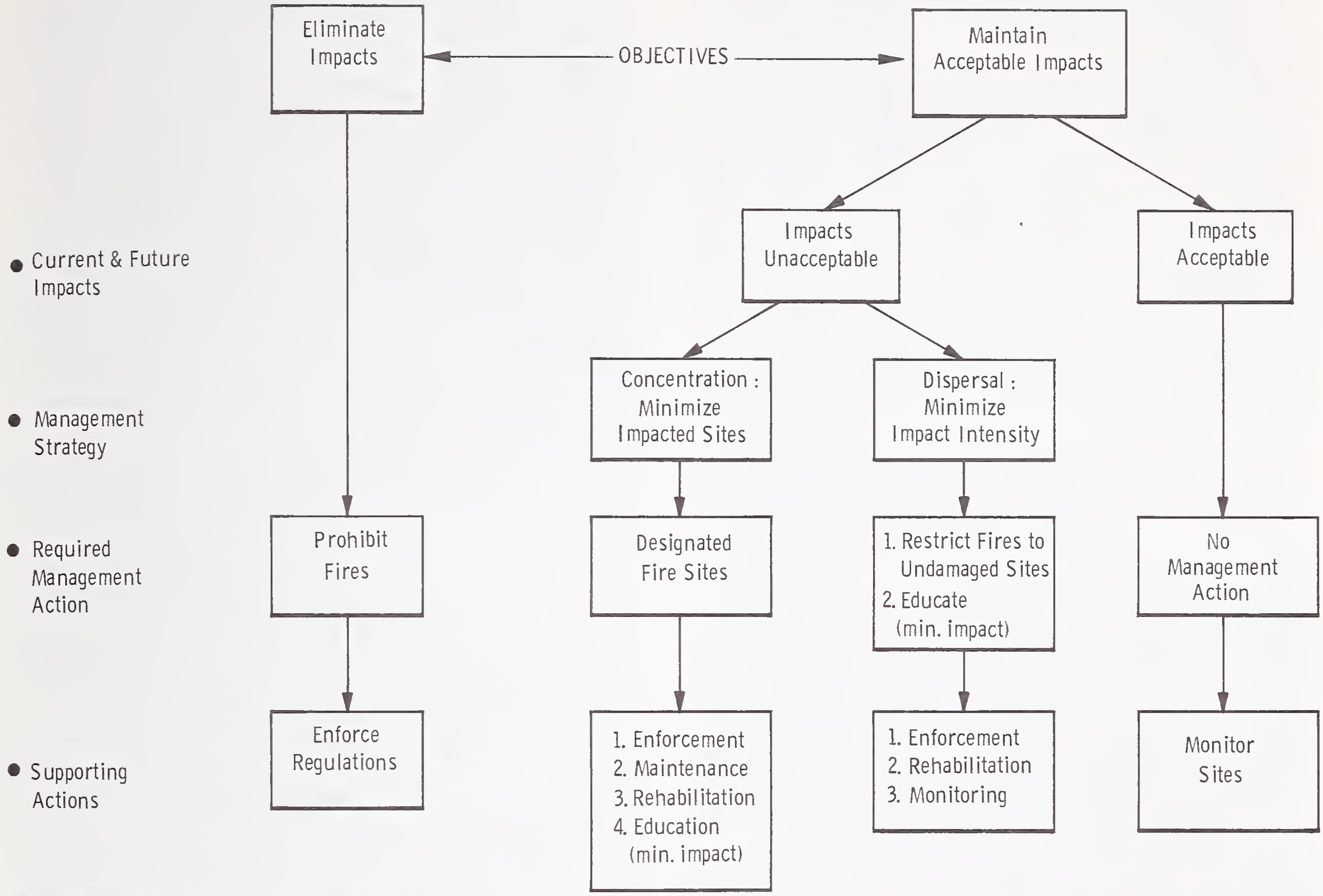

Figure 7.—Flow chart to aid in developing strategies and actions designed to manage backcountry campfires. Several strategies might be employed within different zones within one backcountry area.

Figure 8.—Wood fires should be prohibited in heavily used timberline sites where firewood is scarce.

Figure 9.—Old fire sites can spoil the beauty of meadows, particularly near popular lakes, even though loss of vegetation is often minimal.

Table 1.— Campfire policies for wildernesses and proposed wildernesses that permit overnight use (from 1978-79 census, USDA Forest and Range Experiment Station, Missoula, Mont.)

Campfire policy	Agency				
	FS	NPS	FWS	BLM	Total
	Percent (Number)				
Prohibit fires	1	40	50	0	15
	(1)	(19)	(17)	(0)	(37)
Permit fires	99	60	50	100	85
	(159)	(28)	(17)	(11)	(215)
Restrict fires to designated sites	6	39	6	0	10
	(9)	(11)	(1)	(0)	(21)
No restrictions	84	36	94	100	79
	(133)	(10)	(16)	(11)	(170)
Discourage wood fires	28	70	6	36	29
	(37)	(7)	(1)	(4)	(49)
Promote use of used sites	18	50	0	9	18
	(24)	(5)	(0)	(1)	(30)
Promote use of undamaged sites	19	0	0	0	15
	(25)	(0)	(0)	(0)	(25)
Total areas reporting	160	47	34	11	252

Currently, 15 percent of all existing and proposed wilderness units that permit overnight use prohibit campfires (table 1). Most of these areas have little firewood, being located in arid regions or at high altitudes; many of them receive little use, however. In some cases fires are prohibited because of high fire danger. Many other areas prohibit fires in certain zones. For example, Yosemite National Park prohibits fires above 9,600 ft (2 926 m) and Olympic National Park prohibits fires above 3,500 ft (1 060 m) on the west slope of the mountains and above 4,000 ft (1 220 m) on the east slope.

Although visitors in many areas oppose campfire prohibitions (Lucas 1980), in Mount McKinley National Park 69 percent of the respondents to a survey had no opposition to a proposed "no campfire" policy.[1] In 1978, 75 percent of the respondents in a user survey supported the prohibition that had been established (Womble 1979). In Yosemite National Park, Absher and Lee (1978) found that although visitors who camped close to trailheads disliked fire prohibitions, visitors to more remote sites favored them. A substantial number of visitors use gas-fueled stoves (Lucas 1980), so other areas might also find a surprising lack of opposition, particularly if opportunities to have campfires can be provided elsewhere, either through internal zoning or alternative backcountry areas.

Management personnel must inform users of a campfire prohibition and enforce it. Dissatisfaction can be greatly reduced if users know about the prohibition when planning their trip, and understand the reasons for the prohibition.

If campfires are to be allowed, the next step is to decide whether or not current impacts are unacceptable or are likely to become so in the foreseeable future. Impacts, whether ecological or esthetic, are unacceptable when they are inconsistent with management objectives such as maintaining the integrity of natural ecosystems and the quality of the visitor's backcountry experience. Unacceptable impacts are most likely to occur where use is high, wood is scarce, impacts are highly visible, and management objectives stress strict resource protection and an undisturbed landscape. Future impacts should also be considered and planned for.

[1]Buskirk, Steve. 1976. Unpublished data. Mount McKinley National Park, Alaska.

Where impacts are considered acceptable, no management actions are required but the situation should be periodically monitored. Currently, most areas that allow campfires (79 percent) place no restrictions on campfire use. Only the Park Service has restrictions in more than 50 percent of the areas which allow fire.

Of the areas that have no restrictions, 29 percent discourage the use of wood fires. Again, the Park Service takes a particularly strong management stance, discouraging the use of fire in 70 percent of the areas with no restrictions.

Where impacts are considered to be unacceptable, management action is required. A basic and extremely important choice must be made for each zone between (1) attempting to minimize the intensity (that is the degree or amount) of impact on all sites by dispersing use so that sites have time to recover between periods of use, or (2) attempting to minimize the number of sites with campfire impacts by concentrating use on as few sites as possible.

Although both strategies can be effectively employed in different parts of a backcountry area, the two strategies are basically in opposition; a compromise between the two, within a small area, is likely to be ineffective. If managers decide to minimize the number of impacted sites, it would also be desirable to reduce impacts on these sites. This does not minimize impacts on all sites, however, as impacts on the sites of concentrated use will still be substantial. Minimizing impacts on all sites will only be successful if use is distributed between a large number of sites. This will result in some impacts on many sites.

Although it might seem desirable to have a moderate number of moderately impacted sites, this situation is usually unattainable because once use of campsites exceeds very low levels, near-maximum levels of impact occur (Wagar 1964; Fichtler 1980; Cole 1981). Total impacts can be most effectively minimized by managing for either a large number of lightly impacted sites (dispersal) or a small number of heavily impacted sites (concentration).

The Dispersal Strategy

Dispersal is a rest-rotation strategy in which use is so dispersed that individual sites have time to fully recover from firewood collection and burning before being used again. In this way large numbers of sites are impacted, but impacts are relatively minor and are not cumulative. The problem is insuring that impacts remain minor and that use is infrequent enough so that sites are not reused before they have had time to recover.

Only the Forest Service consciously attempts the dispersal strategy; 16 percent of the Forest Service areas that allow fire encourage visitors to use previously unused sites. However, many other areas promote this strategy—perhaps unconsciously—by scattering all fire rings, even on consistently used sites.

Dispersal is most appropriate in zones or areas in which use levels are low, attractions are scattered, and potential campsites are numerous. It is likely to be ineffective in areas that are relatively heavily used because campsite use is likely to occur too frequently to allow full recovery. Even if use levels are low, this strategy is inappropriate where the number of potential or desirable campsites is limited. It will also be ineffective in areas used by novices or visitors who have not been adequately exposed to minimum-impact camping techniques, and in areas without sufficient funding or staff to adequately educate visitors.

MANAGEMENT PRESCRIPTION

Two management actions are absolutely necessary to make dispersal work. Visitors must be highly educated in minimum-impact camping techniques, and they must be dispersed widely enough so they do not camp on previously used sites. Both of these are necessary. Visitors must be educated **before** use dispersal is attempted. Otherwise, impacts will be spread throughout the area.

Both actions are difficult. Most attempts to voluntarily disperse use have met with rather limited success (Schomaker 1975; Lucas 1981), although Krumpe (1979) describes a technique that was successful in Yellowstone National Park. If visitors will not voluntarily disperse, then rationing by trailhead or travel zone is likely to be the most effective course of action. Once this is accomplished, however, it may be even more difficult to get people to use previously unused sites. In a study in Great Gulf Wilderness, N.H., for example, Canon and others (1979) found that all campers used previously used sites despite being asked "not to camp at sites that show clear signs of previous use."

At this time we do not know how long recovery periods should be. Undoubtedly, this varies greatly between ecosystems. In subalpine forests it appears that use of the same site once a year probably does not insure full recovery (Cole 1981). Therefore, until more accurate estimates of recovery rates are available for more ecosystem types, it would be prudent to keep occupancy frequencies to less than one night per year.

Minimum-impact campfire use and camping techniques are of the utmost importance. (Guidelines for establishing an educational program and suggested practices are discussed in detail in a subsequent section) No evidence of previous use should be left; otherwise, too much repeat use will occur.

SUPPORTING MANAGEMENT ACTIONS

Necessary supporting actions include (1) impact monitoring, (2) rehabilitation of impacted sites, and (3) enforcement. If visitors are poorly educated in minimum-impact camping techniques, or if use levels are too high, impacted sites will start appearing throughout the area. Impact monitoring is needed to judge whether the strategy is working. A simple inventory of all evidence of human use (for example, fire rings, blackened rocks, charcoal, informal trails, and so on), noting type of impact and location, would probably be sufficient. Some examples of monitoring systems can be found in Frissell (1978), Shreiner and Moorhead (1979), and Parsons and MacLeod (1980). This inventory should be most intensive in the most heavily visited areas, but it should periodically cover the entire area.

Rehabilitation, which will be discussed in more detail later, is particularly important. All impacted sites need to be closed and rehabilitated so they do not encourage repeat use. All fire rings should be removed and all evidence of fire eliminated. Enforcement may also be necessary to keep visitors off impacted areas and to ensure the use of minimum-impact techniques. This can be costly because visitors are so widely dispersed. If enforcement becomes a problem, it might be worth reassessing the practicality of this management strategy. Any need for increased patroling and enforcement should be identified by the impact monitoring system.

ADVANTAGES AND DISADVANTAGES

This strategy promotes the type of wilderness situation that most managers and many users probably equate with the "wilderness ideal"; evidence of human impact is minimal and crowding is generally avoided. Moreover, wood depletion should not be a problem because use levels are so low. Campfire impacts do occur, but the visitor usually does not notice them and they are never allowed to intensify.

This strategy is difficult to implement in many areas and has the potential for widespread damage if it fails. The key to this strategy is keeping impacts to a minimum on all sites. So many sites are impacted that if the intensity of impacts cannot be kept to a minimum, site impacts will proliferate.

Managers should be cautious about attempting dispersal, particularly in parts of backcountry areas that are frequently used. Where visitor concentrations are low in relation to potential campsites, however, and visitors are willing to disperse and practice low-impact camping techniques, dispersal could perpetuate an ideal low-density, low-impact wilderness atmosphere.

The Concentration Strategy

Concentration recognizes that impacts are the inevitable result of use, and that total impacts can be minimized by confining impacts to as few sites as possible. Sites of concentrated use become substantially impacted, but most of the backcountry area remains unaffected by camping and campfires.

Currently, only 10 percent of the existing and proposed wilderness areas that permit fires have regulations that require visitors to camp on designated sites. Another 14 percent of the areas that permit campfires do not regulate use, but encourage visitors to camp on previously used sites. These areas have adopted the use concentration strategy. This strategy is particularly prevalent in the National Park Service; 57 percent of the areas that allow fires attempt to concentrate these impacts. This compares with 21 percent in the Forest Service, 6 percent in the Fish and Wildlife Service, and 9 percent in the Bureau of Land Management.

The concentration strategy is most appropriate in zones or areas in which the manager cannot insure against repetitive use of sites (areas that are heavily used or where potential campsites are limited). It is appropriate when visitors are not well educated in minimum-impact camping techniques. As the more conservative of the two strategies—the strategy less likely to cause widespread damage if ineffective—concentration is also appropriate in areas where the manager is unsure what to do. Finally, it is appropriate in areas of high fire danger.

Concentration is inappropriate in lightly used areas where wood is scarce because it leads unnecessarily to firewood depletion. In areas where wood supplies are meager and use levels are high, dispersal will not solve the problem either, and campfires should be prohibited. Concentration of campfires is also inappropriate in lightly used zones or areas that are managed to offer particularly high levels of solitude and naturalness.

MANAGEMENT PRESCRIPTION

The major action required is to insure that all fires are built on designated or previously used sites. On each campsite a permanent fire site should be designated, whether it is a constructed fireplace or an officially sanctioned fire ring. This action will confine the effects of fire to a small area, although these fire sites will be highly altered by repeated burning.

The distribution of fire sites throughout the area can vary with management objectives. Clustered sites are easier to administer and patrol than more widely distributed designated sites. They reduce campsite solitude and compound some ecological problems, however, such as bear encounters, waste disposal, and depletion of local wood supplies.

Managers must also decide how many sites to have and whether a reservation system is necessary. In any local area there should be at least enough sites available to handle the maximum number of parties anticipated at one time. The number of sites necessary to accommodate a given amount of use is lowest with a reservation system because the need for "overflow" sites is eliminated. Nevertheless, the need to make reservations greatly reduces spontaneity and freedom, extremely important elements of a wilderness experience.

SUPPORTING MANAGEMENT ACTIONS

Site maintenance and enforcement of camping regulations are extremely important actions. These sites will be frequently used, so they must remain clean and desirable. For example, litter, partially burned logs, charcoal, horse manure, and visitor-built "improvements" can make a campsite undesirable (Lee 1975). Although a visitor education program could minimize most of these problems, managers should patrol sites and clean up where necessary. Otherwise, visitors may start to camp offsite. If new fire rings are constructed by visitors, all rings but the officially sanctioned ring should be removed. Because the number of sites is minimized, patrol is less costly than in a dispersed situation.

The most significant management problems will probably be depletion of local wood supplies and illegal camping. Wood depletion problems could be reduced by encouraging visitors to use stoves for cooking, build small fires, and gather wood offsite; by distributing designated sites widely; and by locating sites in productive forests. If visitors respond to depletion by damaging standing trees, local campfire bans may be the only alternative.

Illegal campfires may result from general dissatisfaction with camping on previously used sites, dissatisfaction with specific campsite conditions, or insufficient available sites in a specific locality. General dissatisfaction can be alleviated by allowing offsite camping without fire, allowing dispersed campfires in other zones, or suggesting alternative areas with a dispersed program. Dissatisfaction with specific conditions can be reduced by providing more site information and increasing site maintenance. Solving problems of too few available sites will require either a reduction in use or an increase in the number of sites.

Minimum impact practices are less crucial than in areas practicing the dispersal strategy, but they can help to reduce impacts. The most important practices to teach include keeping fires small and of short duration, using small pieces of downed wood, and conscientious cleanup. Visitors should **not** destroy fire rings.

ADVANTAGES AND DISADVANTAGES

The advantage of this strategy is that a large number of visitors will alter relatively few sites even if they know little about minimum-impact camping and even if few potential campsites exist. This strategy guarantees near pristine conditions throughout the vast majority of the area. This strategy also recognizes that the majority of visitors use the same few sites anyway.

The major disadvantage is that localized impacts are severe and are immediately obvious to the visitor. Although there is little to suggest that visitors are substantially bothered by these impacts, obvious impacts may result in less respect for a low-impact ethic. Tree damage, as wood supplies become depleted, may be a particularly troublesome example. The visitor also loses the freedom to choose a new fire site.

MINIMUM-IMPACT CAMPFIRE TECHNIQUES

Educating users to practice minimum-impact techniques requires that managers implement programs to convince users of the **need** to use proper techniques and show users **which** techniques to use to meet management objectives for local areas and **how** to properly use those techniques. Appropriate techniques in one situation may be inappropriate in a different situation. The following discussion will focus first on some principles for establishing an education program and then address specific techniques that minimize campfire impact.

Establishing an Educational Program

The following are some points to be considered when establishing a minimum-impact campfire program. Additional sources of information include Fazio (1979) and Bradley (1979).

1. Focus the message. Clearly state the problem and the minimum-impact techniques that would avoid the problem. The appropriateness of techniques will vary with management strategies.
2. Identify the audience. Concentrate your educational effort on the user groups that contribute most to the problem.
3. Decide where to contact the audience. Some visitors can be contacted at home, if they write for information. Local residents can be reached with special programs in the community or on radio and television; college students can be reached on campus. In most cases a large proportion of the visitors enter the wilderness at a few popular trailheads, so these are particularly efficient locations for contacting visitors. The most effective educational programs will attempt to contact different segments of their audience in several different locations, placing top priority on locations where "problem users" can be reached (Bradley 1979).
4. Select communication methods. Personal contact by trained staff and audiovisual programs have been particularly effective (Fazio 1979). Brochures are also effective, but are most useful if people have them in the planning stages of outings (Lime and Lucas 1977). Minimum-impact information is being included in guidebooks and how-to-do-it manuals, but a great deal more is needed. Mass media such as television and newspapers have potential, but failed to reach the right audience in one test (Fazio 1979). Demonstrations and field programs that

show how to use techniques can be used in town or at popular trailheads. Again, a variety of media tailored for the appropriate audience and directed toward users in town, at trailheads, and within the wilderness will be most successful.

5. Monitor education success. Some system of gaging how well objectives are being met is necessary so that time and money are not wasted and so that programs can be improved. This can be tied into monitoring campfire impacts and the incidence of noncompliance with rules and regulations.

Techniques

Although impact will not be eliminated if a fire is built, it can be reduced depending on which techniques are used and how carefully they are applied. **Note that recommendations for areas concentrating campfires differ from those for areas attempting dispersal.** Four topics will be discussed: location of fire sites, construction, fuel collection and burning, and cleanup.

Location (applicable only in areas of dispersed campfires):

1. Avoid sites that appear to have been previously used—those with trampled plants, litter or charcoal, sooty rocks, or disturbed soil. Limit stay to one night if trampling or other evidence of human use begins to show.
2. Try to find an area with as little natural vegetation as possible. River bars, beaches, and rocky areas are good sites for fires if cleaned afterwards.
3. Consider wildfire safety but avoid clearing a large area of combustible material. Where fire danger exists use fire pans, existing bare ground, or do not build a fire.

Construction (applicable only in areas of dispersed campfires, listed in order of preference):

1. *Fire pan*: Building the fire in a fire pan made of any convenient fireproof material is the most effective way to minimize impacts (fig. 10). Ideally, pans should have legs or some other means to support the pan at least 6 inches (15 cm) above the ground. Otherwise, the ground will be scorched.

Figure 10.—Collapsible, lightweight (24-ounce [680-g]) grill makes an inexpensive fire pan.

2. *Bare mineral soil*: Where there is bare mineral soil, such as sandy or rocky areas, fires can be built directly on the soil. Avoid blackening rocks by cooking on a stove, using a grill with folding legs, or hanging pots from a dead branch. If it has not rained recently, soak the fire site prior to use. Soaking will reduce heat transfer into the soil, so less of the organic matter and soil biota will be destroyed.
3. *Litter and duff*: Where vegetation is sparse, but the mineral soil is covered by organic layers of twigs, needles, leaves, and products of their decomposition, build the fire in a pit excavated down to the gritty, lighter colored inorganic mineral soil.
4. *Flat rock*: A fire can be built on a large, flat rock covered with several inches of mineral soil. In many areas suitable rocks will not be available, so users should not count on using this technique.
5. *Dense vegetation*: Digging a pit may be the only possible technique in areas with a dense ground cover. This is a difficult technique, however, with a high potential for damage. Therefore, we do not think it should be widely recommended. If this method is used, a flat-bladed digging tool must be carried. Dig a pit as deep as the plant's roots, if possible. Remove the plants and soil in as large a block as possible and place them adjacent to the pit. This material should be kept moist. After cleaning up after the fire, the block of plants and soil should be carefully replaced, making sure there are no air pockets underneath or around the sides to cause drying of roots or subsequent settling of the soil. Water the site well to help the plants recover from any damage.

Fuel use (applicable to all fires):

1. Wood should be gathered only in areas where it is abundant. Some should always be left so the area does not look denuded.
2. Only dead and down-on-the-ground wood should be used. Never use standing trees or branches on standing trees. If a choice exists, softwood fuels are preferable to hardwoods as they transfer less heat into the soil (Fenn and others 1976).
3. The wood collected should be hand breakable and as dry as possible. Small pieces of dry wood are easiest to burn down to ash so that no charcoal is left. It is important to leave larger pieces of wood. Leaving the axe and saw at home lightens the load.
4. Take only as much wood as you will need; do not stockpile. This will reduce trampling and facilitate cleanup.
5. In foraging for firewood do not walk on areas that appear trampled. Disperse impact so that trails will not be formed.
6. Keep the fire small and of short duration to conserve wood for others. A small, brief fire will also cause less impact to the soil. Use a stove for cooking meals and a campfire for a short evening period or to dry clothing.
7. Food scraps and plastic are difficult to dispose of by burning. Complete combustion requires a hot fire, which wastes wood and transfers large amounts of heat into the soil. Incomplete combustion makes cleanup difficult. Foil, often used to line paper packets, does not burn.

Cleanup (steps 1-2 apply to all areas; steps 3-6 apply only to areas of dispersed use):

1. At least 30 minutes before finishing with the fire, begin to burn all remaining wood and charcoal to ash. Do not add more wood, except very small pieces that might be needed to help burn stubborn charcoal. Keep heaping the coals and unburned pieces into the center where the heat is greatest. Fan as needed to help combustion.
2. When only white ash remains, soak with water to be sure no live coals are left. Crush and grind any charcoal remnants to powder.
3. Scatter any excess firewood far from the site.
4. When you are certain that the fire is out—feel for live coals—scatter the ash widely in inconspicuous places (fig. 11).

Figure 11.—Minimum-impact fire built on a sandy site where the potential for damage was low. Only small pieces of wood were used (a). After the wood was burned to ash, the ash was scattered and all evidence of use was easily eliminated (b).

5. If rocks were used, replace them in their original locations and configurations, charcoal side down.
6. Mask any remaining signs of disturbance by filling in pits and spreading native material that most nearly matches the surroundings. Leaves, needles, small branches, and loose soil are some materials to use. Take small amounts of such material from widely scattered spots, so no place will look used.

REHABILITATION OF CAMPFIRE SITES

Campfire sites may need rehabilitation wherever campfires are prohibited. If repetitive use of a site is undesirable, the entire campsite will need rehabilitation. In dispersed use areas rehabilitation will be necessary wherever camping or campfire impacts become obvious. Where the concentration strategy is practiced, only illegal fire sites will need rehabilitation work.

To rehabilitate a site, managers must first prevent reuse and additional damage to the site. Often it is also necessary to prepare the soil and reestablish vegetation cover. The following recommendations, developed primarily from work in the Pacific Northwest, stress key points in order of application. Other useful references on rehabilitation include Hartmann and Kester (1975), Miller and Miller (1977), and Cole and Schreiner (1981). Local extension agents, nurseries, colleges, and garden clubs can often provide additional information about soil and vegetation conditions and useful techniques.

Preventing Reuse of a Site

Remove as much evidence of previous use as possible so others are not attracted to the site.

1. Eliminate the fire ring. If the holes from which the rocks came are evident, replace the rocks in their original positions. If the blackened parts of rocks are still conspicuous and the soot cannot be removed, the rocks should probably be hidden in an inconspicuous place. Cleaning sooty rocks is difficult but sometimes is successful with a stiff bristle or wire brush. Some success with alcohol and commercial fireplace cleaners has been reported, but others have had as much success with water.
2. Remove all trash, including small pieces of foil mixed in with the charcoal. If it is not possible to separate the trash—for example, melted plastic often makes a congealed mass of charcoal—then all of the material should be packed out (fig. 12).
3. Remove all surface charcoal and partly burned wood. Scatter this debris widely, far from the site.
4. Scatter any remaining firewood far from the site.
5. Remove or repair any other signs of use, such as makeshift seats, sticks cut for tent pegs, rock windbreaks, etc.
6. If a site continues to be used, it may also be necessary to discourage use by temporarily posting signs, cordoning the area off with string, using natural debris to block access trails, or embedding rocks or logs in the site to make it less attractive (fig. 13). If none of these actions are successful, consider designating the site as a legal fire site and allowing no dispersed fires in the vicinity.

Figure 12.—Backcountry ranger cleaning up an old fire site.

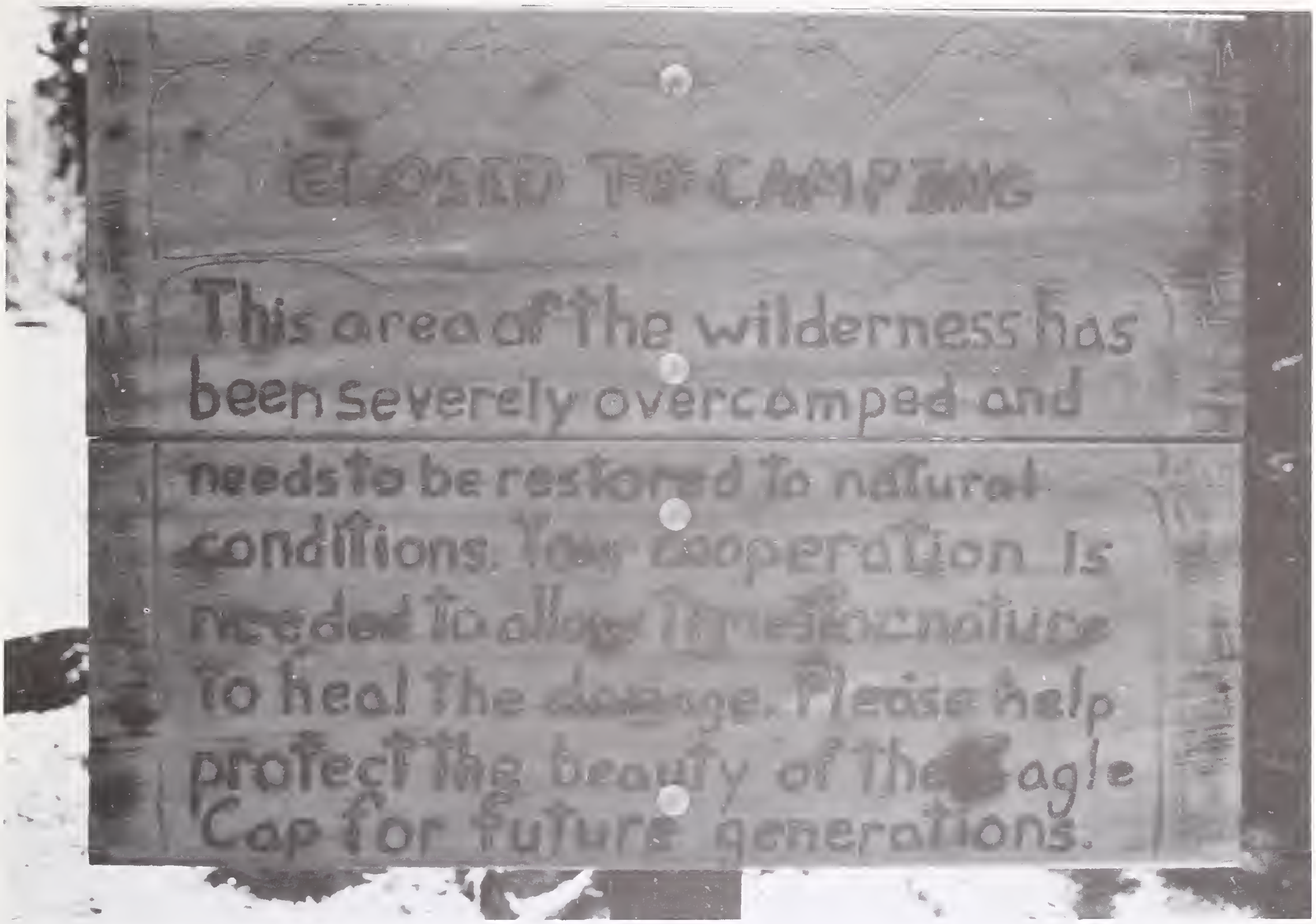

Figure 13.—Signs may be necessary to prevent use of closed sites.

Preparing Soil

If the site was on a naturally bare area, or the bare ground of a designated or acceptable campsite, or was only used a few times, revegetation may not be necessary. In this case merely remove any debris and cover the fire site with a thin layer of mineral soil.

Where revegetation is desired, additional soil preparation will usually be helpful. Cultivate the surface soil to a depth of at least 4 inches (10 cm). Mix in locally collected decaying plant material or commercial peat moss. Fertilizer can also be added, although it has seldom significantly improved revegetation success in backcountry areas.

It is important to match soil amendments to the species to be planted. Campfires usually reduce soil acidity (Cole 1981); therefore, peat moss or raw organic matter should be added where the plants to be grown prefer acid soils. This applies to many of the species that inhabit higher elevation coniferous forests. Grasses prefer more neutral soils, however; so rehabilitation of grasslands would be facilitated by decreased acidity and acidic materials should not be added.

Reestablishing Vegetation

Once a site has been cleaned and the soil prepared, one of several alternative revegetation methods may be applied. These include transpanting whole plants, plant cuttings, seeding, or merely facilitating natural revegetation. The use of cuttings is difficult and will not be discussed here. Readers are referred to Miller and Miller (1977) for more information.

NATURAL REVEGETATION

Under some very favorable circumstances, natural revegetation may occur without much assistance within a few growing seasons. For example, nonforested sites with plentiful moisture and lush adjacent ground cover and sites where fires did not burn so hot and deep that organic matter and underground plant parts were completely destroyed may recover rapidly. On most sites unassisted revegetation will take decades (fig. 14). If site rehabilitation is an important element of a campfire or campsite management program, assisted revegetation should be tried if funding and manpower are available. (In many backcountry areas rehabilitation is done entirely by volunteers, which minimizes costs.)

TRANSPLANTING

This is usually the quickest way to get plant cover on a site; but the technique is time consuming and disturbs adjacent areas from which plants are removed (fig. 15).

1. Select species adapted to grow on the site. Species that naturally colonize disturbed sites are good choices, as are plants that reproduce vegetatively. Obtain transplants from some distance away and, if several plants are needed, take them from scattered locations to disperse damage. Choose relatively short plants with healthy looking foliage.
2. Water both the plants to be transplanted and the area to be transplanted one day before transplanting.
3. Dig around the plant, vertically rather than in toward the plant, so roots are not damaged. If possible, excavate sections of

Figure 14.—Little natural revegetation has taken place on this fire site (unused for 13 years) in Mt. Rainier National Park.

turf, at least 8 inches (20 cm) in diameter, rather than individual plants. Lift the plant or turf out by supporting it under the root ball (roots and soil) rather than by pulling on the stem. Plant as soon as possible, being careful to always keep plants cool, moist, and out of direct sunlight.

4. Place the plant upright in a hole slightly larger than the root ball of the transplant. Make certain that roots are not doubled over upon themselves. Fill in the excess space with organic matter and soil. When tamped down firmly, the top of the root ball should be slightly below the ground surface to facilitate watering and to reduce the risk of damage from frost heaving.

5. Water thoroughly. If the weather is very warm, it may be necessary to water the plants daily or to shade them. Where this is not feasible, survival rates can be increased by pruning some flowers, leaves, and branch tips and by including large root balls.

6. Add a layer of mulch 0.5 to 1.5 inches (1 to 3 cm) thick over the transplanted area and around the base of the transplants. Alternative materials include leaves, pebbles, excelsior matting, jute netting, decaying wood, grass, or any other material that insulates yet allows free movement of air and moisture. Lightweight mulches that might blow away have to be anchored by limbs, stones, or similar objects.

7. Repair damage around the holes from which the transplants were taken. Fill the holes with soil and mulch the area.

Figure 15.—A small warning sign and string boundary mark transplanted vegetation in Eagle Cap Wilderness, Oreg.

SEEDING

In the Pacific Northwest, seeding is best done in the fall when seeds are naturally dispersing, but it can be done any time mature, viable seed is available.

1. Use seed from the same plant species as are found near the site. Ripe seeds can usually be shaken off plants. Be familiar with special germination requirements, such a scarification or stratification, of the species used.
2. Either scatter the seeds over the prepared soil bed and cover with about 0.5 inch (1 cm) of fine soil, or poke holes 0.5 inch (1 cm) deep, drop seeds in, and cover. Tamp the soil and mulch as described for transplanting.
3. Water, if seeding is done during or just prior to dry weather.

Monitoring

Rehabilitation success can be greatly increased if records of work from a sample of sites are kept. Photographs, with date and treatment noted, may be sufficient, or more detailed field measurements can be taken. In the long run the time invested in testing can save a lot of wasted effort and unnecessary damage to resources.

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Discusses techniques for managing the ecological and esthetic impacts of backcountry campfires. Four sections cover the impacts of collecting and burning wood, management alternatives for various situations, minimum-impact campfire building, and rehabilitation of campfire sites.

KEYWORDS: backcountry management, campfires, recreational impacts

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